

Deacon's Challenge

No. 18 Answer

A tumour marker X is used to guide a decision on chemotherapy after the resection of the main tumour mass. The concentration decays exponentially. If the half-life of the tumour marker is less than 75 hours, then this is indicative of tumour clearance and chemotherapy is withheld. If the half-life is greater than this, it indicates that residual disease is present and chemotherapy is indicated. The precision of the assay is such that measurements can be safely made at a precisely timed interval of more than 36 hours from two or more days after surgery.

The level of X at 50 hours post surgery is 1756 ng/L and at 94 hours it is 1050 ng/L. Calculate the half-life and indicate whether you can say with confidence whether chemotherapy needs to be given.

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For exponential decay:

$$C_t = C_0 e^{-K_d t}$$

Taking logs gives the linear form:

$$\log_e C_t = \log_e C_0 - K_d t$$

Where C_t = concentration at time "t"
 C_0 = initial concentration (i.e. concentration when $t = 0$)
 K_d = elimination rate constant
 t = time

We are given the concentrations of tumour marker at two different times:

$$\begin{array}{l} 1756 \text{ ng/L at } 50 \text{ h post surgery} \\ 1050 \text{ ng/L at } 94 \text{ h} \end{array}$$

These values can be substituted into the above equation to yield two simultaneous equations:

$$\begin{array}{l} \log_e 1756 = \log_e C_0 - 50 K_d \\ \log_e 1050 = \log_e C_0 - 94 K_d \end{array}$$

Subtraction of the second equation from the first eliminates the $\log_e C_0$ term, and the resulting equation can be solved for K_d :

$$\begin{array}{l} \log_e 1756 - \log_e 1050 = -50 K_d - (-94 K_d) \\ 7.47 - 6.96 = 44 K_d \end{array}$$

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$$K_d = \frac{7.47 - 6.96}{44} = \frac{0.51}{44} = 0.0116 \text{ h}^{-1}$$

The relationship between K_d and the half life ($t_{1/2}$) is:

$$T_{1/2} = \frac{0.693}{K_d}$$

(This relationship can be obtained by substituting $t = t_{1/2}$ and $\log_e C_t = \log_e C_0/2$ into the first order rate equation. NB. $\log_e 2 = 0.693$)

$$\text{Therefore } t^{1/2} = \frac{0.693}{0.0116} = 60 \text{ h (2 sig figs)}$$

Since the half-life is less than 75h and the time interval is 44h and the 1st sample was taken at least 48h after tumour removal we can conclude that chemotherapy can be withheld.

Exam tip: Equations which are important to commit to memory will from now on be boxed-in.

Question No. 19

The literature (particularly American literature) often contains analytical data presented in units other than SI units. Convert the following results to SI units: (Atomic mass C = 12, O = 16, N = 14, H = 1, Ca = 40)

- Express 99 mg/dL plasma glucose as mmol/L glucose
- Express 14 mg/dL BUN (Blood urea nitrogen) as mmol/L urea
- Express 2.50 mEq/L plasma ionized calcium as mmol/L

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